NEARSHORE SURFACE CURRENTS, SOUTHEASTERN TEXAS GULF COAST

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ABSTRACT

Thirteen monthly releases of drift bottles at 18 stations along the Texas Gulf Coast offshore from Mustang and Padre Islands indicate that the nearshore surface circulation in depths of eight fathoms and less is strongly influenced by the local wind circulation. During the summer months of strong southerly winds, the bottles drift to the north along the shoreline. In the winter months characterized by alternating northerly winds of frequent winter storms and the prevailing southerly winds, bottles drift either north or south along the shoreline depending on the winds active during and immediately preceding their drift at sea. Anomalous southerly drift often occurs during tmies of transition between winter and summer wind regimes.

INTRODUCTION

Several lines of evidence suggest that nearshore currents and littoral drift have a net annual convergence in the vicinity of central Padre Island. This is reasonable insofar as these currents are wind derived. The wind regime in this area is bimodal with north to east winds accompanying Arctic and Pacific cold fronts during fall and winter and onshore, south to southeasterly, trade winds prevailing during spring and summer (Fig. 1). Since a wind vector meeting a coast at any oblique angle would have a longshore as well as an onshore component, a vector which is perpendicular to the coast indicates current convergence on a concave coast. And the annual resultant vector based on velocity, duration and direction is perpendicular to the central Texas coast approximately at Port Aransas.

The currents generated by winds exist as water translated alongshore seaward of the surf zone and as longshore currents in the surf zone generated by oblique wave approach. The second process results in longshore transport of sand and coarser sediment; and its net effects can be interpreted from characteristics of sediment distribution, erosion and accumulation. Distribution of heavy mineral suites (Bullard, 1942; Van Andel and Poole, 1960), sand size modes (Hayes, 1965). and shell material (Watson, 1968) all indicate a littoral drift convergence zone on central Padre Island. Pelecypod valve sorting also can be related to direction of wave approach. Although shell sorting trends cannot be correlated

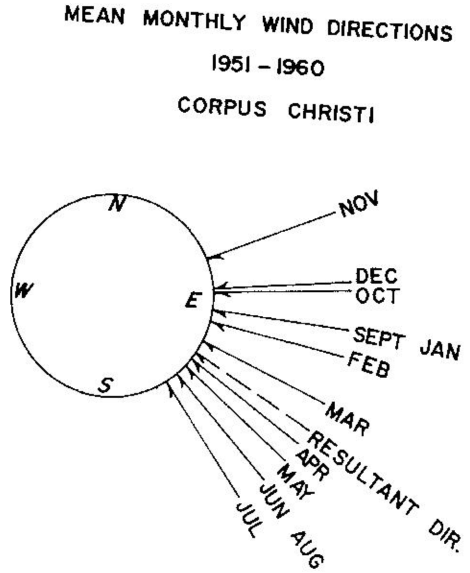


FIG. 1. Mean Monthly Wind Directions for Corpus Christi 1951–1960. Directions shown represent the average of the monthly vector resultants determined for 10 years of wind data collected at Corpus Christi. The RESULTANT DIR. shown is the vector sum for the entire 10 year period. Vector magnitudes are calculated as a vector product of velocity, duration, and direction.

quantitatively with littoral drift, they do reflect the seasonal fluctuations in the wind-wave regime (Behrens and Watson 1969, Table 2).

The purpose of this study was to measure surface water movement on the shallow shelf beyond the surf zone in order to determine whether or not currents in this region reflect the convergence deduced from the beach sediment characteristics. The area of study was restricted to the sandy bottom, barrier shore-face between depths of three and eight fathoms.

Currents on the continental shelf have been studied both by direct current meter measurements and by drift bottle studies. Drift bottle techniques were used by Kimsey and Temple (1962, 1963) in a study of currrents on the entire continental shelf between the mouths of the Mississippi and Rio Grande Rivers. Again, a seasonal shift was observed with west to southerly flowing currents being driven by north to easterly winds during the winter regime and north to easterly flowing currents being driven by summer southerly winds. Littoral drift driven by waves generated by these same winds could produce the net convergence observed in the sediments. Transitional periods between the summer and winter regimes were often characterized by onshore winds and actual nearshore current convergence on the central Texas coast.

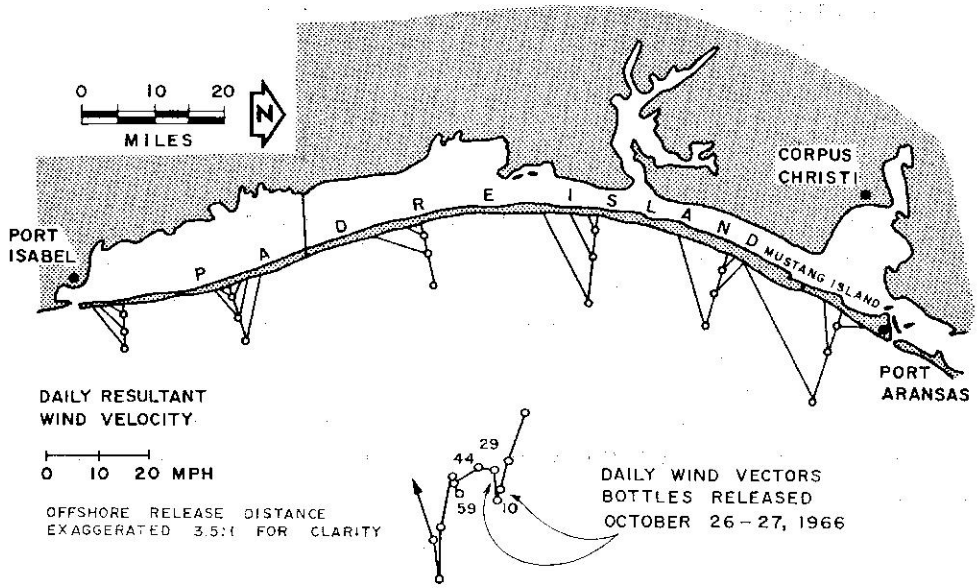
Counter currents against the prevailing wind conditions were sometimes indicated along the south Texas coast by data from the four stations nearest shore in this area. However, only two of these stations were inside the eight-fathom contour. It was hoped ... counter current.

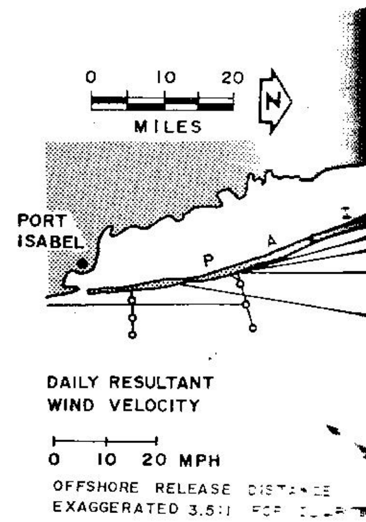
Unweighted drift ... coast between Port ... monthly from October ... along six traverses ... depths of three, six and ... at each station. Recovery ... only two bottles were ... six and eight fathom stations.

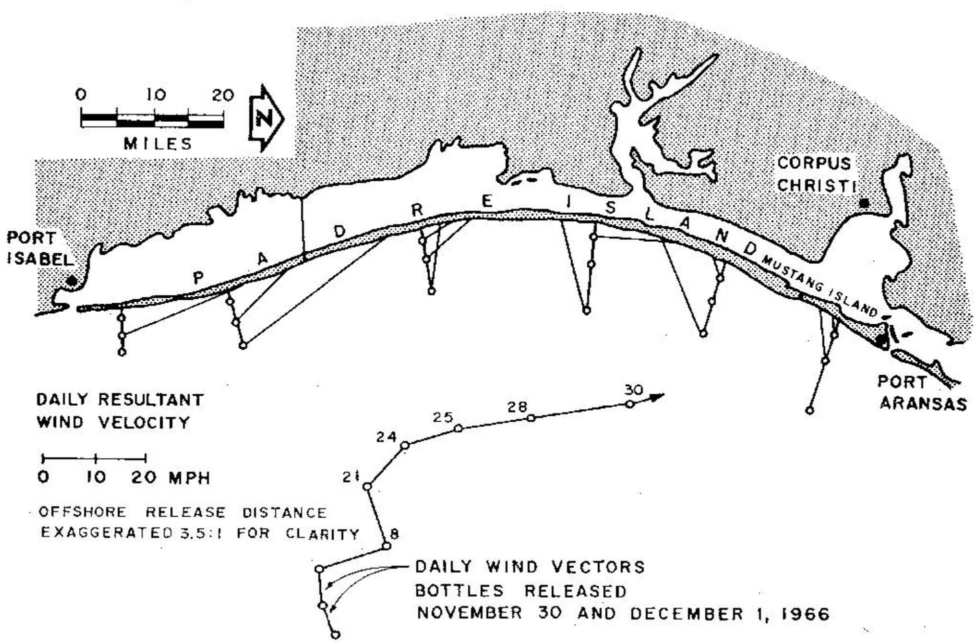
For the first four months ... of two days. Subsequently ... hour period.

Figures two through ... gathered during the study ... release stations along ... The distance from shore ... The lines drawn from the ... path that the bottles could ... they were found on the beach ... Office at Corpus Christi. ... The arrow at the end of the ... the wind was blowing. The ... of daily wind vectors ... month were released. The ... the cumulative number of ... instance, on the releases for ... bottles were found by ...

Qualitative analysis of ... months (nine out of 13 ... component of the local ... notable during these times. The ... pattern of southerly drift ... drift in response to southerly ... August, September and December ... and February, 1967) local ... convergence on central Padre ... annual convergence of littoral ... December, 1966 and January ... particularly anomalous pattern ...


0 10 20
MILES
N
PORT
ISABEL
CORPUS
CHRISTI
P A D R E I S L A N D
MUSTANG ISLAND
PORT
ARANSAS
DAILY RESULTANT
WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE
EXAGGERATED 3.5:1 FOR CLARITY
29
44
59
10
DAILY WIND VECTORS
BOTTLES RELEASED
OCTOBER 26 – 27, 1966


0 10 20
MILES
N
PORT
ISABEL
P A
DAILY RESULTANT
WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE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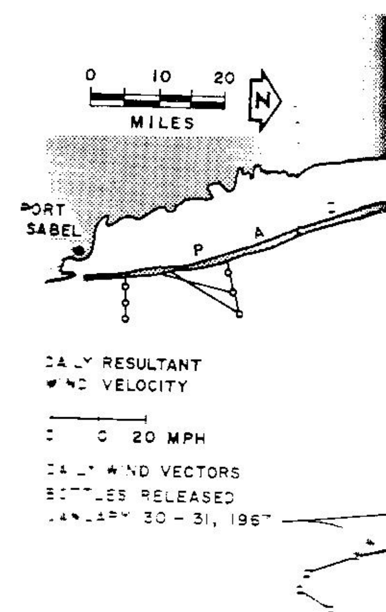
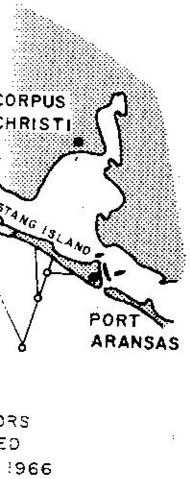
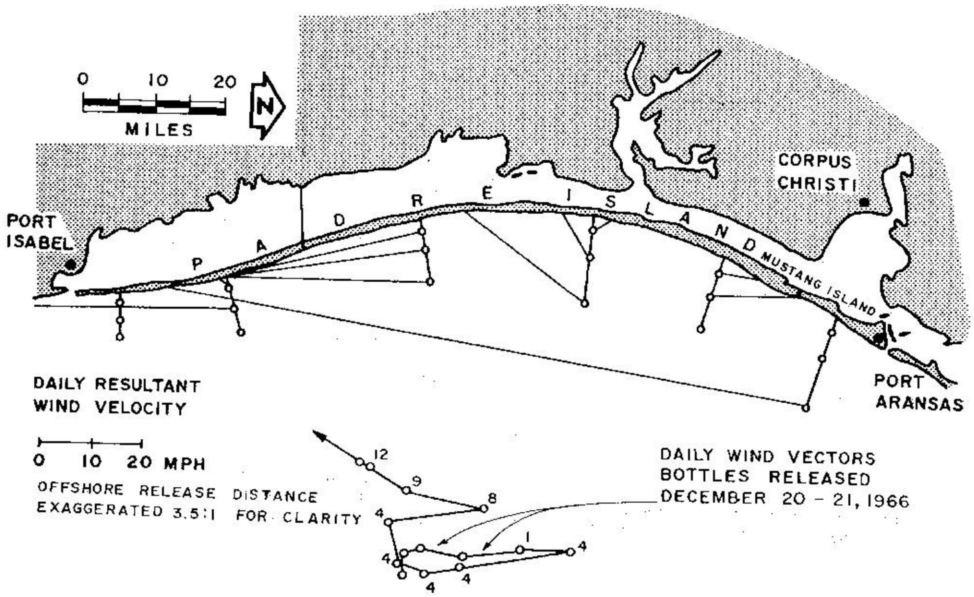
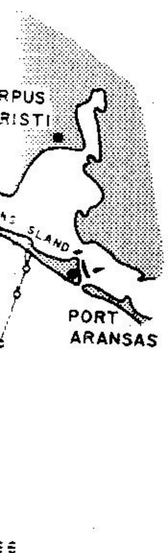
MILES
N
PORT
ISABEL
CORPUS
CHRISTI
P A D R E I S L A N D
MUSTANG ISLAND
PORT
ARANSAS
DAILY RESULTANT
WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE
EXAGGERATED 3.5:1 FOR CLARITY
30
28
25
24
21
8
DAILY WIND VECTORS
BOTTLES RELEASED
NOVEMBER 30 AND DECEMBER 1, 1966

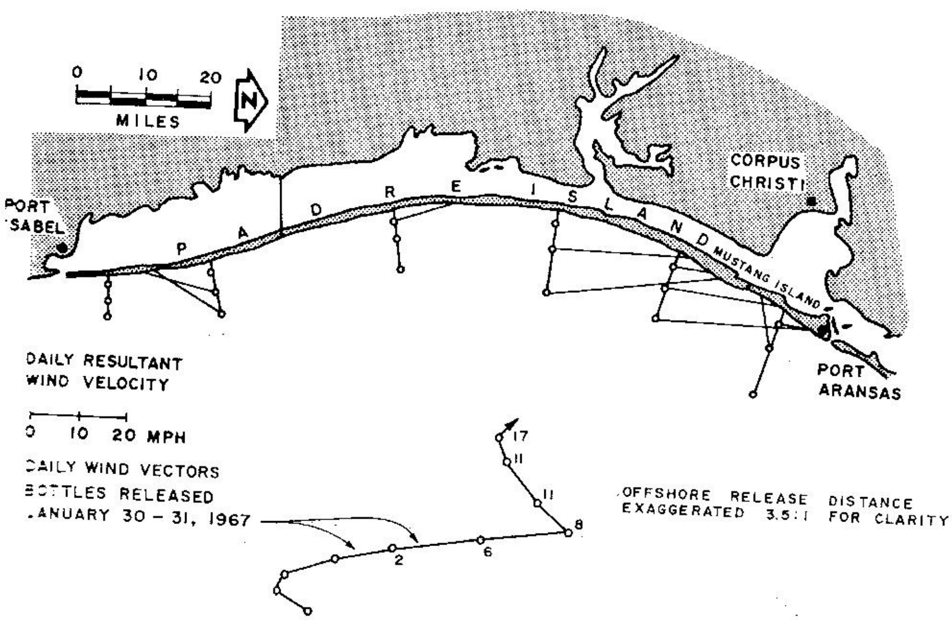

0 10 20
MILES
N
P A
RESULTANT
VELOCITY
20 MPH



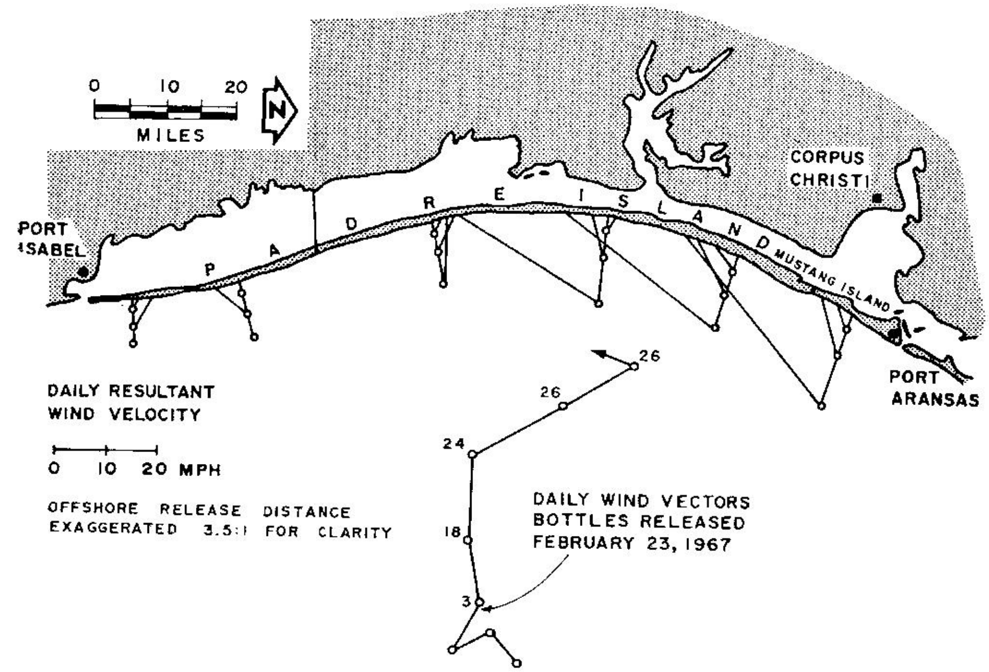


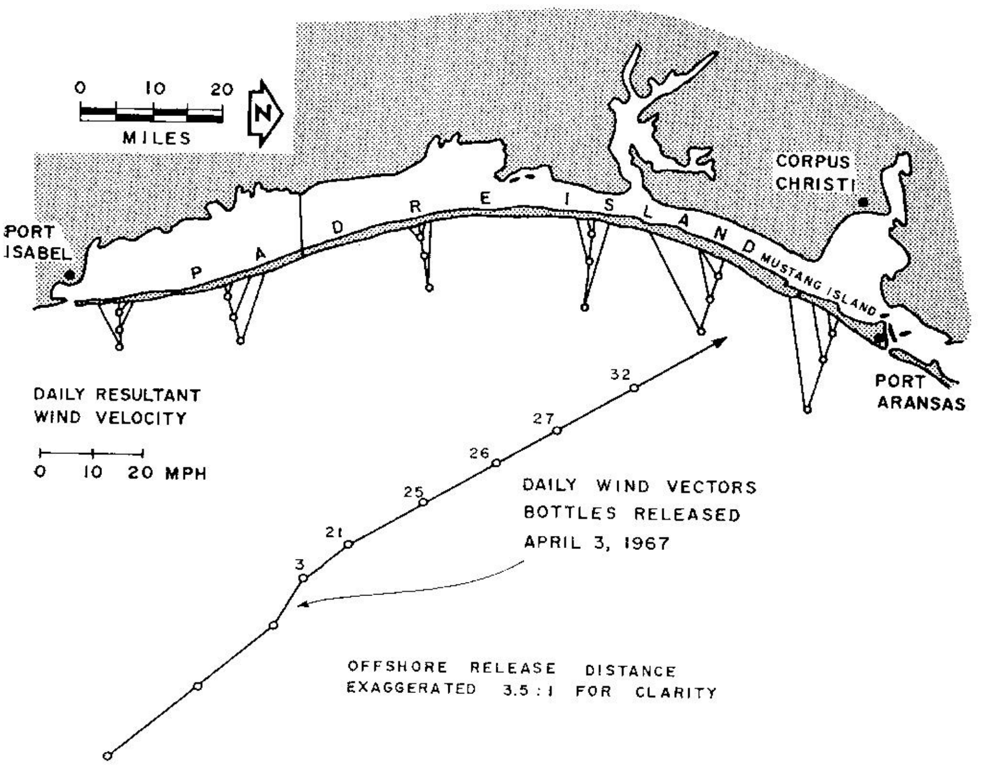
0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
DAILY WIND VECTORS BOTTLES RELEASED DECEMBER 20 - 21, 1966
12
9
8
4
1
4
4
4
4

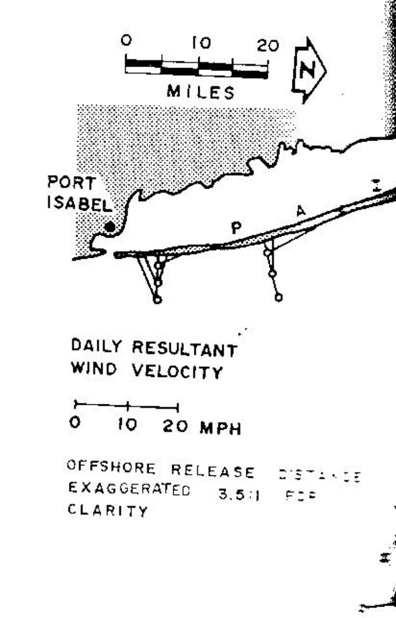


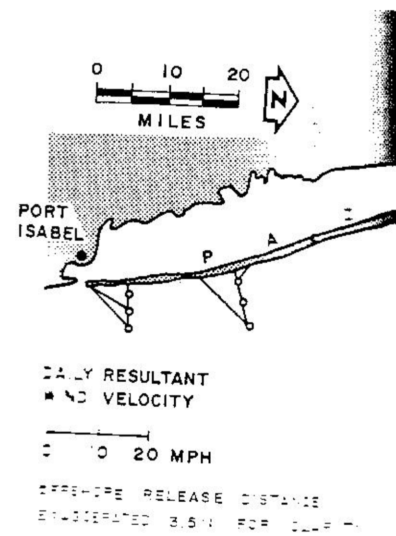


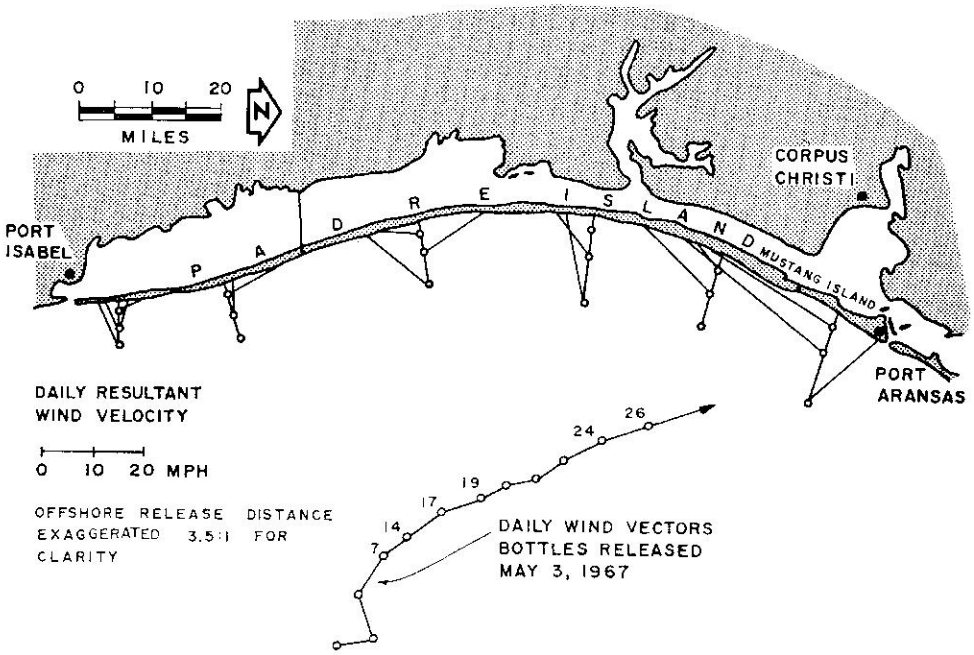
0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
DAILY WIND VECTORS BOTTLES RELEASED JANUARY 30 - 31, 1967
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
17
11
11
8
6
2

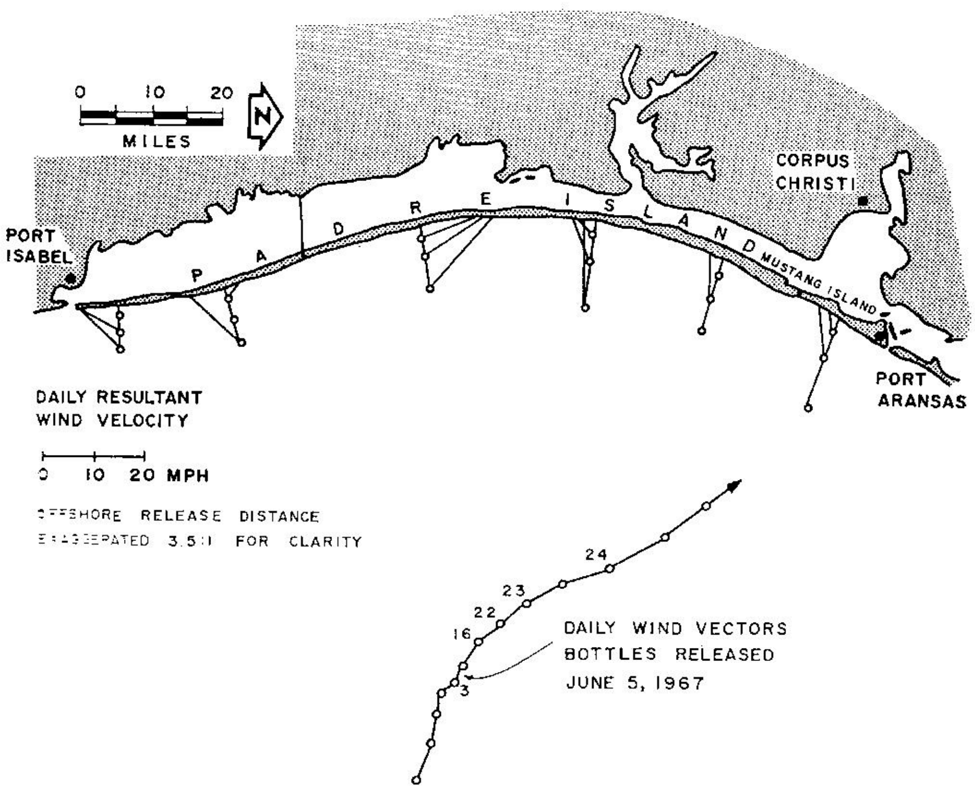

0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
DAILY WIND VECTORS BOTTLES RELEASED FEBRUARY 23, 1967
26
26
24
18
3

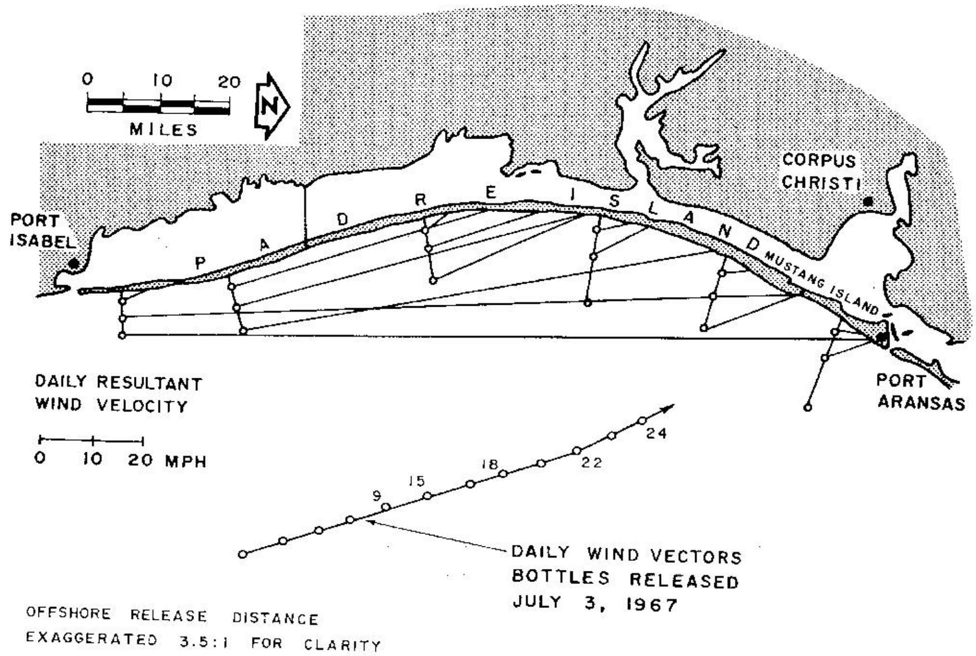

0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
DAILY WIND VECTORS BOTTLES RELEASED APRIL 3, 1967
32
27
26
25
21
3
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY


0 10 20
MILES
N
PORT ISABEL
P A
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
CLARITY

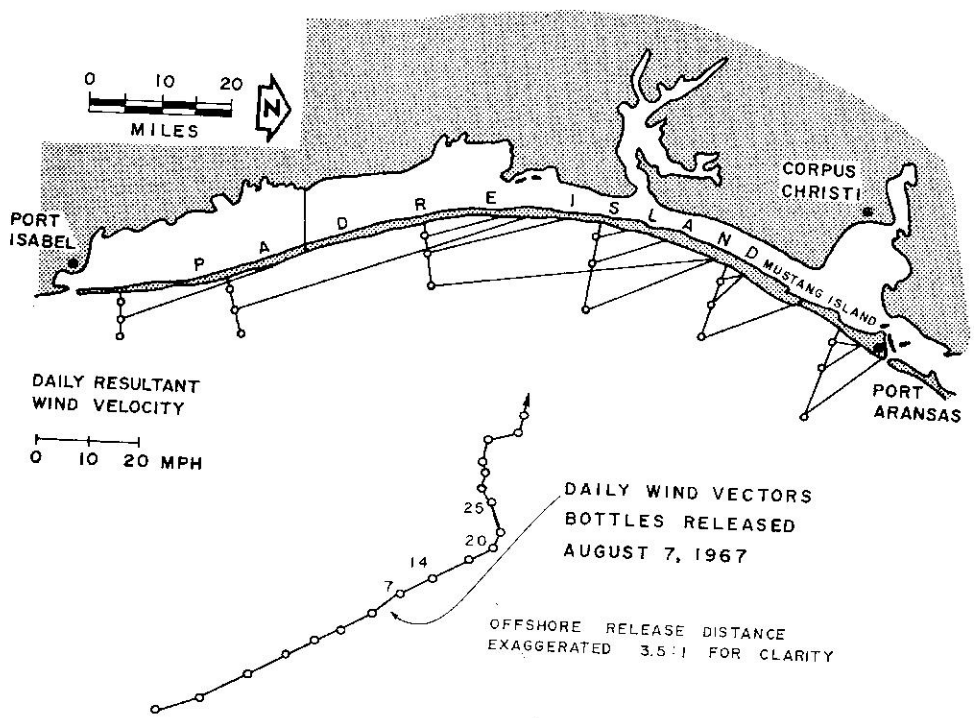

0 10 20
MILES
N
PORT ISABEL
P A
RESULTANT
VELOCITY
20 MPH


0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
DAILY WIND VECTORS BOTTLES RELEASED MAY 3, 1967
7
14
17
19
24
26

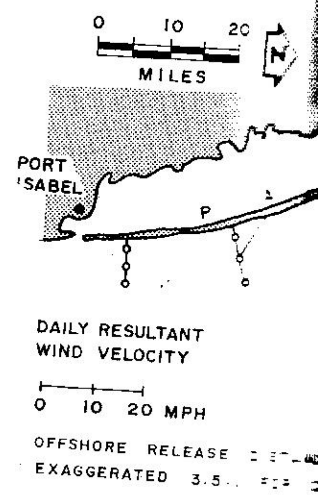

0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
DAILY WIND VECTORS BOTTLES RELEASED JUNE 5, 1967
3
16
22
23
24



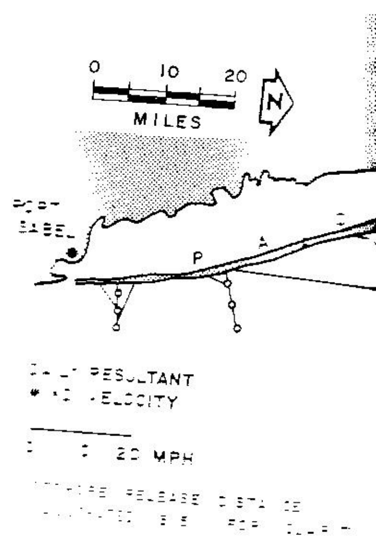
0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
9 15 18 22 24
DAILY WIND VECTORS BOTTLES RELEASED JULY 3, 1967
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY



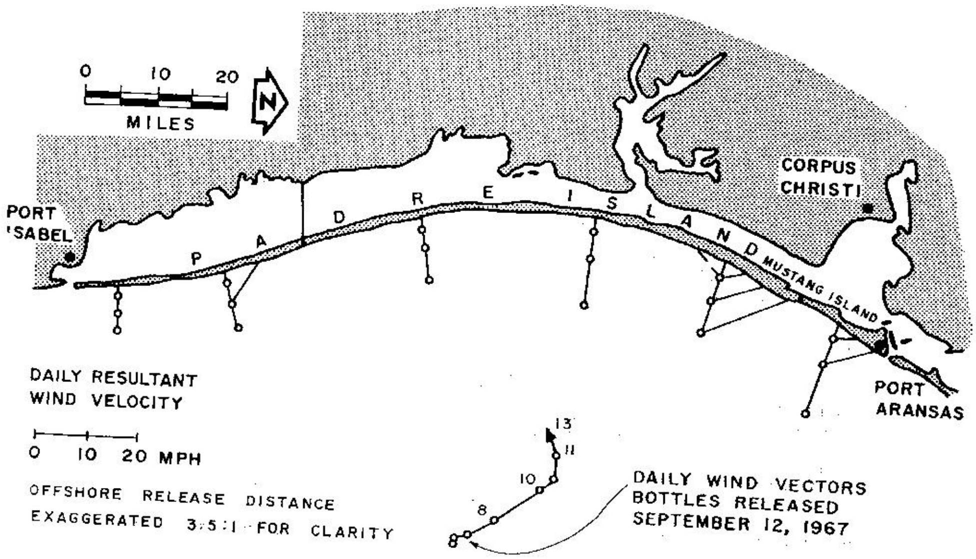
0 10 20
MILES
N
PORT ISABEL
P A D R E I S L A N D
MUSTANG ISLAND
CORPUS CHRISTI
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
7 14 20 25
DAILY WIND VECTORS BOTTLES RELEASED AUGUST 7, 1967
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY



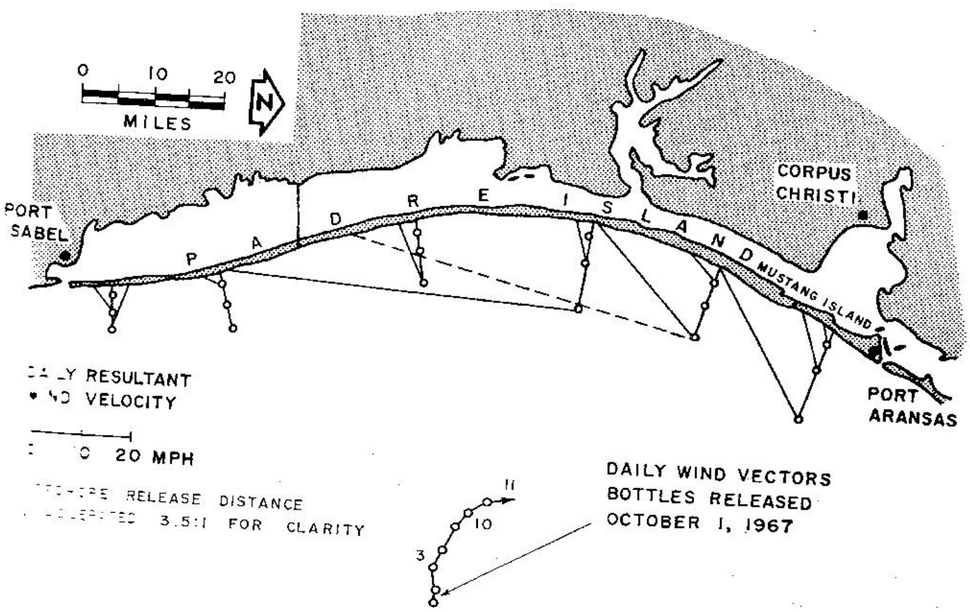
0 10 20
MILES
PORT ISABEL
P
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE
EXAGGERATED



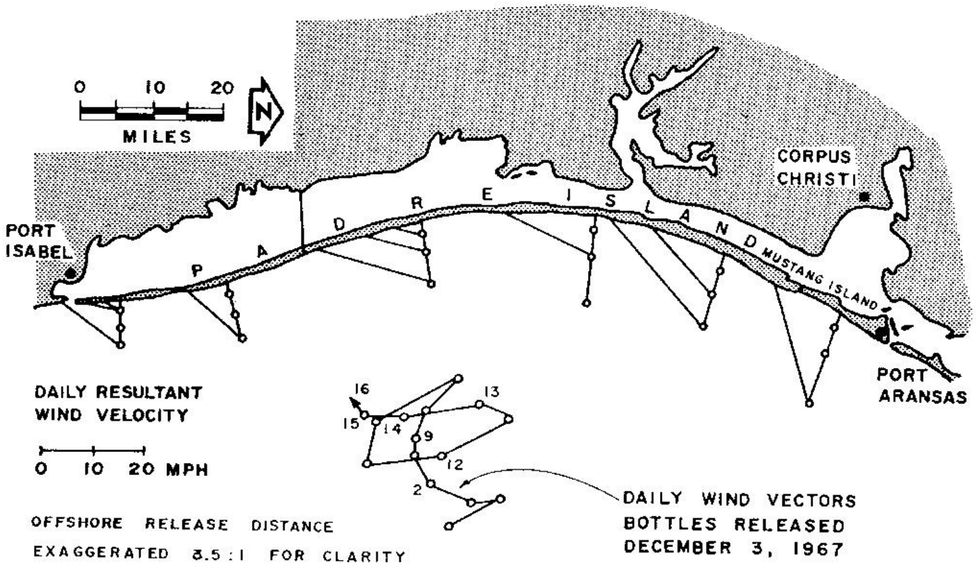
0 10 20
MILES
P A
20 MPH



0 10 20
MILES
N
PORT ISABEL
CORPUS CHRISTI
P A D R E I S L A N D
MUSTANG ISLAND
PORT ARANSAS
DAILY RESULTANT WIND VELOCITY
0 10 20 MPH
OFFSHORE RELEASE DISTANCE EXAGGERATED 3.5:1 FOR CLARITY
13
11
10
8
DAILY WIND VECTORS BOTTLES RELEASED SEPTEMBER 12, 1967



0 10 20
MILES
N
PORT SABEL
CORPUS CHRISTI
P A D R E I S L A N D
MUSTANG ISLAND
PORT ARANSAS
RESULTANT
VELOCITY
20 MPH
RELEASE DISTANCE
3.5:1 FOR CLARITY
11
10
3
DAILY WIND VECTORS BOTTLES RELEASED OCTOBER 1, 1967



The second major observation is that during four months transitional between summer and winter wind regimes (April, May, June and October, 1967) there was significant drift against the prevailing local winds. Only about 35 to 40% of the bottles drifted as would be predicted. In all cases southerly drift predominated while northerly drift should have prevailed at all stations. This anomalous drift during the spring months resulted in a convergence on central Padre Island. This drift is opposite in direction to the counter current observed off southern Padre Island by Kimsey and Temple (1963).

DISCUSSION AND CONCLUSIONS

Drift bottle movements observed in this study indicate that most of the currents on the shallow shelf off Mustang and Padre Islands, Texas can be generated by local winds as measured in Corpus Christi. Nearshore currents flow in opposite directions during winter and summer just as do the prevailing winds. During periods of transitional weather, especially in the spring, southward surface drift is often counter to the local southerly winds. Apparently this area is affected by significant currents generated by winds representative of winter conditions in another, probably more northern part of the Gulf while summer winds have begun to or are still blowing in the south Texas region.

Both beach sediment distribution and the net annual wind vector for Corpus Christi indicate that net annual littoral drift converges along the central Texas coast; but the sediment distribution indicates the nodal point is on central Padre Island while the wind data suggests that it is on northern Mustang Island.

This study shows a similar convergence of nearshore surface currents. The similarity between nearshore surface currents and littoral drift along the Texas

ast is not surpri
ttoral drift is driv
arily by waves fro
driven primarily b
other circulation sy

We wish to thank
Bureau of Commercial
drift bottles and paying
landings. We especially
Kenneth N. Baxter of
many of the bottle releas

BEHRENS, E. W. and
swash zone. *J. sedim.*
BULLARD, F. M. 194
geol. Soc. Am. 53
HAYES, M. O. 1965.
emphasis on hurrica
KIMSEY, D. B. and R.
western Gulf of Mex
logical Laboratory.
———. 1963.
nual Laboratory Rep
Texas. p. 25–27.
ANDEL, T. H. an
Mexico. *J. sedim. P*
N, R. L. 1965.
Texas, Austin.

coast is not surprising since both are primarily generated by local winds. The littoral drift is driven primarily by waves generated from local winds and secondarily by waves from distant storms while the nearshore surface currents are also driven primarily by local winds, they are apparently driven secondarily by some other circulation system active principally during spring months.

ACKNOWLEDGMENTS

We wish to thank The United States Department of the Interior Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory at Galveston, Texas for providing the drift bottles and paying rewards to the many individuals who found and reported drift bottle landings. We especially appreciate the cooperation of Milton J. Lindner, Robert F. Temple, and Kenneth N. Baxter of that Laboratory. Mr. John Batterton was kind enough to act as pilot for many of the bottle release flights. Mrs. Judith Watson drafted the figures.

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